CHAPTER 3
GENERATION OF THE FREE-SPEED PROFILE

3.1 INTRODUCTION

The free-speed profile is one of the input data of the MST and can be generated either by the Model of Time and Fuel Consumption (MTC) (Zaniewski and Swait, 1979), developed by the GEIPOT Research on the Interrelationships of Highway Costs, or by the SPEEDS computer program, elaborated by the Main Roads Department of Western Australia (1977). The profile thus generated consists of a description of the behavior of the various vehicle classes (in terms of speed), as if each vehicle were covering the simulated section without interference from other vehicles. It is one of the basic inputs and the foundation upon which the effect of congestion will be introduced in the simulation. Currently, the MTC and the SPEEDS program are distinct from the MST, but they may well be incorporated into it as subroutines.

3.2 MODEL OF TIME AND FUEL CONSUMPTION (MTC)

For the MST to compute the time and fuel outlays of a vehicle, when its performance is conditioned by the presence of other vehicles on a given highway section it is necessary to establish a table of the speeds at which the vehicle would run were it alone. This table should be generated by a free-flow traffic model. In the case of Brazilian conditions, the Model of Time and Fuel Consumption (MTC) is used, since this model incorporates the speed and consumption equations obtained from experiments with vehicles representative of the national fleet, on sections of the country's highway network including the most varied characteristics.

In the operation of the MTC, the segments with homogeneous characteristics in terms of grade, alignment, surface type and condition are delimited, and the influences of the above factors on vehicle performance, as described in the basic flow chart of the MTC (Figure 3.1), are successively computed.

3.2.1 *Input Data*

The geometric elements (grade and alignment), as well as the

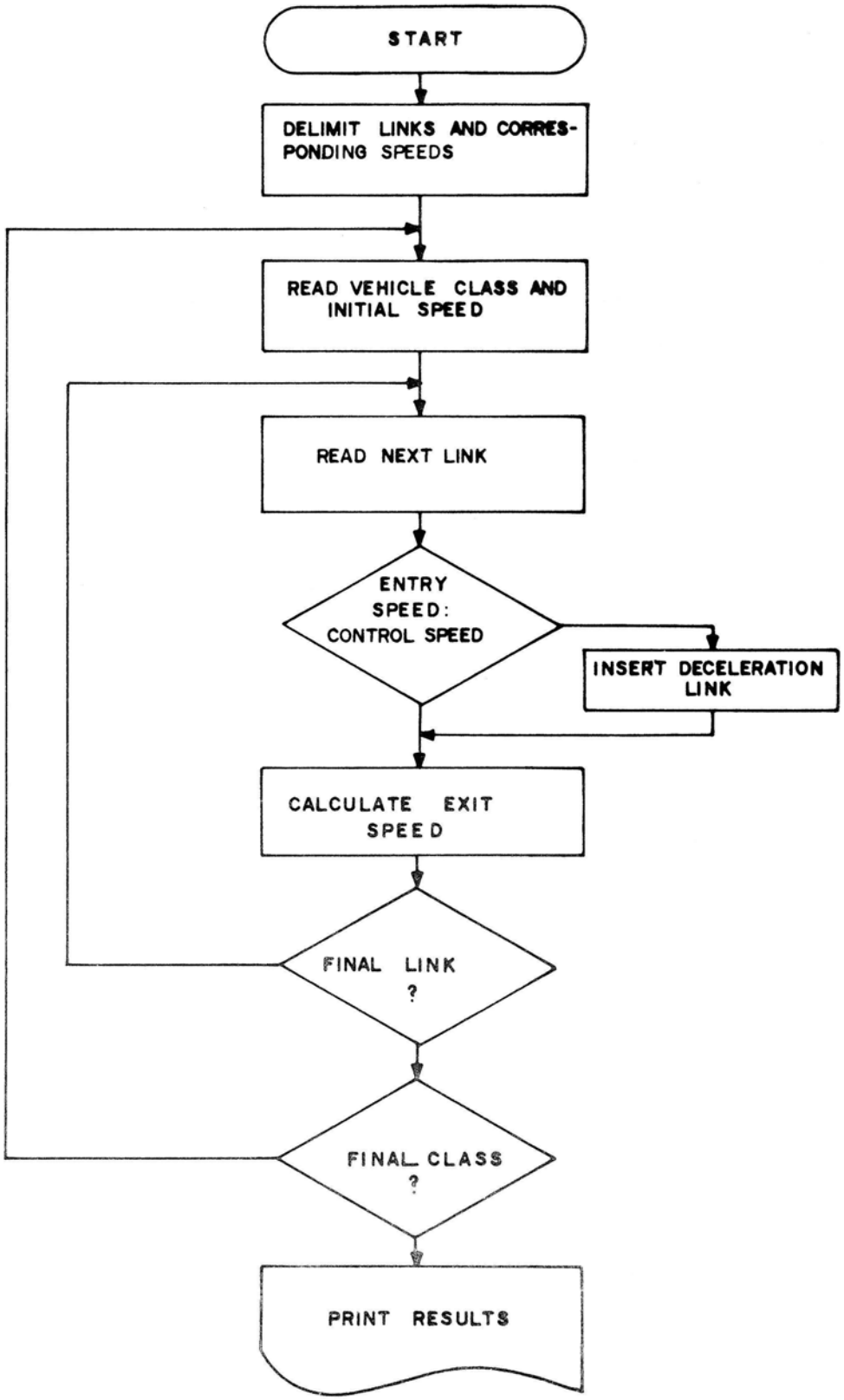

FIGURE 3.1 - BASIC FLOWCHART OF THE MTC.

surface type of the section analyzed, are normally included in designs or updated inventories of highway authorities. The surface condition is a measurable characteristic of each section and will have a numerical value representative of its roughness, designated Roughness Quotient (QI).

The Model can analyze six vehicle classes: automobiles, buses, empty utilities, loaded utilities, empty trucks and loaded trucks. Both classes of trucks can be further broken down into the following types: light gasoline-powered and light, medium and heavy diesel-powered trucks. Up to four power/weight ratios are permitted for each class and type. An entry speed should be ascribed to the first link analyzed, for each vehicle class.

3.2.2 *Simulation Process*

Given the input elements from the inventory or highway design, the MTC links together a succession of segments that are uniform as to grade, curved or straight alignment, and surfacing type and roughness. Other data are also inserted, such as speed limits (existent or established by the user). Based on equations developed through actual observations of traffic on the Brazilian highways, the Model ascribes an average speed on curves to each class of vehicles. In the same way, the Model establishes a steady-state speed for each grade. By steady-state speed is meant the speed at which vehicles, according to their class and load, tend to reach stability on roads of any grade. Consequently, a speed limit and a steady-state speed are implicitly ascribed to each link.

A vehicle can enter a restricted speed section at any velocity. Depending on the grade, type of surfacing, roughness and geometry, the vehicle tends to its own steady-state speed. If the vehicle attains this steady-state speed before reaching the end of the link, it will maintain it from that point onward. Therefore, travel time, fuel consumption and distance traveled are computed both for the stage of steady-state speed and for the previous stage. The rate of fuel consumption for each class of vehicles (in ml/km) is the average of the consumption rates of each subclass (power/weight) weighted by the percentage of vehicles in each subclass. This rate is then multi-

plied by the time spent on each stage of the course, to give the consumption on the link.

Following this, the vehicle enters the next link with the same speed it left the previous link, and the same process is repeated.

However, if the next link is subject to a lower speed limit, the program goes back to a previous stage, substitutes the previously computed speed mode with another whose deceleration rate matches the speed required on the link in question, and recalculates fuel consumption for the new situation.

This procedure goes on till the final link, when it is repeated for another class of vehicles. At conclusion, data involving speed, distance covered, travel time and fuel consumption for each vehicle class on the link in question are printed. The process is repeated in the same manner on the return trip.

3.2.3 *Example of Application*

In Table 3.1, the input data for a typical link of the Fernão Dias highway are presented, while Table 3.2 includes the results of the first class of vehicles calculated (automobiles). Both speed and fuel-consumption functions shown therein correspond to formulas derived from actual observations and tests performed on typical sections in different regions of the country. These and other aspects of the MTC are described in detail in Volume 9 of this report.

3.3 *THE SPEEDS MODEL*

The SPEEDS Program reads a highway survey file and generates the following results:

(a) A control-speed file of the link (data on speed limit, horizontal curvature and surface type). The control speeds (maximum speeds imposed by road conditions or by legal limits) are derived from the functional relations developed from traffic experiments or pertinent traffic legislation.

TABLE 3.1 - MTC INPUT DATA.

GEIPOT - EMPRESA BRASILEIRA DE PLANEJAMENTO DE TRANSPORTES

PESQUISA ICR SISTEMA DE TRAFEGO
PROGRAMA MTC - MODELO DE TEMPO E COMBUSTIVEL - VERSAO 2.1 (JULHO 1980)

LISTAGEM DOS CARTOES DE ENTRADA

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NUMERO                1         2         3         4         5         6         7         8
CARTAO   12345678901234567890123456789012345678901234567890123456789012345678901234567890

    1    XXXX  VERIFICACAO DO  SOFOT VERSAO 01  -  TRECHO-TESTE 568
    2    11100
    3       8   1   0   1  13   6   6
    4    123456
    5         0.0    +1.4     0.3    +2.5     0.4    +3.5     0.5    +5.1     1.5    +5.0
    6         1.6    +2.0     1.7    -1.0     1.9    -2.5     2.0
    7        80.3    65.3    72.8    69.6    59.6    50.2
    8        63.7    54.9    60.1    57.3    51.4    54.3
    9         1.3     1.6   680.0
   10         0.01     2.0
   11         0.0    36.0     0.1    37.0     0.2    38.0     0.6    39.0     0.7    40.0
   12         0.8    39.0     0.9    38.0     1.0    27.0     1.1    36.0     1.2    37.0
   13         1.3    38.0     1.4    39.0     1.8    40.0     2.0
   14    111   100.0     1.0   100.0
   15    211   100.0    10.0   100.0
   16    311   100.0     1.5   100.0
   17    411   100.0     2.5   100.0
   18    531   100.0    73.0   100.0
   19    631   100.0    73.0   100.0
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